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The Duration of Totality at Navalmoral.

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For the total solar eclipse of 1900 May 28 I have shown, by a comparison of a large number of observations of the predicted and observed durations of totality for several localities, that the eclipse semidiameter of the Moon, adopted by the *British Nautical Almanac*, is too large. (See *Total Solar Eclipse of* 1900, pp. 75–81.) In the present paper I propose to give some details with regard to Navalmoral, whence I observed this eclipse.

For Navalmoral the following data were published by Dr. Downing :—

Adopted position, 5° 34′ W. longitude, 39° 52′ N. latitude.

		G.M.T. h	G.M.T. m	G.M.T. s
Eclipse begins	May 28	2	48	45
Totality „	„	4	6	12
Totality ends	„	4	7	39
Eclipse „	„	5	15	45

	Angle from N. Point. °
First contact	273
Second „	99
Third „	267
Fourth „	93

A note was appended to the effect that the predicted duration of totality (87^s) is perhaps 3^s too long.

The duration of totality at Navalmoral was carefully timed independently by four observers, and we agreed upon a totality of 80^s. Mr. Howarth, F.R.A.S., the Rev. S. J. Johnson, F.R.A.S., and Mr. Southall used only the eye unaided.

I observed with a low-power binocular, of which the right object-glass was fitted with a diffraction grating attached to a prism, so that the beginning and the ending of totality were estimated by the disappearance and the reappearance of the normal solar spectrum. The coincidence in the four estimates seems to afford reasonable ground for believing that the duration of totality was, as nearly as possible, 80^s.

There is thus a loss of at least 7^s to be accounted for, and this may be due to :—(*a*) errors in the lunar tables, (*b*) error in the adopted position of Navalmoral, (*c*) error in the *N.A.* value of the Moon's geocentric semidiameter, which for eclipses is 15′ 32″·65 at mean distance. It is assumed that the *N.A.* eclipse semidiameter of the Sun is correct.

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With regard to (*a*) it should be noted that, as the transit of the Moon over the Sun was practically central, it may be inferred that any allowable error in the Moon's tabular latitude would be insufficient appreciably to alter the duration of totality.

As to (*b*) Señor Iñiguez, of the Madrid Observatory, has courteously supplied the exact position of Navalmoral Church. The coordinates are 5° 32′ 29″ W. longitude, and 39° 53′ 29″ N. latitude, the difference from the originally adopted coordinates being only 1′ 31″ in longitude and 1′ 29″ in latitude.

By *N.A.* data, at mid-totality, $4^h\ 6^m\ 56^s$, G.M.T., the centre of the shadow was in 5° 31′ 45″ W. longitude, and 39° 53′ 40″ N. latitude, coordinates differing by only 44″ of longitude and 11″ of latitude from the position of the church as given by Señor Iñiguez. As we were about half a mile N. of the church we were only some 20″ of latitude N. of the central line, so small a distance that for us the transit of the Moon over the Sun was practically central during totality.

We have now to consider (*c*). Adopting for Navalmoral the data supplied by Señor Iñiguez, and using *N.A.* data for the R.A., Dec., and semidiameters of the Sun and Moon, I have made for $4^h\ 0^m$, $4^h\ 7^m$, and $4^h\ 10^m$, G.M.T., a careful computation of the positions of the Sun and Moon, and obtain a totality duration of 88^s, or just one second in excess of the *N.A.* predicted value. The moment of mid-totality agrees almost exactly with the *N.A.* time, $4^h\ 6^m\ 56^s$. The nearest approach of the centres of the Sun and Moon is about 0″·3, so that, as already pointed out, the transit was practically central. The position angle for second contact is about 93°, that for third contact is about 271°, reckoned eastward from the Sun's north point.

Thus we have really to account for a loss of about 8^s. It will be found that to reduce the duration of totality to 80^s the effective apparent eclipse semidiameter of the Moon, as seen by the observer during totality, must be reduced from its *N.A.* value of 16′ 5″·71 to 16′ 3″·97, a reduction of 1″·74; whilst the geocentric mean semidiameter at the time of totality must be reduced from 15′ 55″·40 to 15′ 53″·68, a reduction of 1″·72, so that, finally, the *N.A.* geocentric mean distance eclipse semidiameter of 15′ 32″·65 must be reduced to 15′ 30″·97, a reduction of 1″·68, corresponding to 3″·36 for the diameter. The Sun's apparent semidiameter at totality comes out as 15′ 46″·59 by *N.A.* data, and is considered to be accurate.

In a paper by Mr. Dyson, giving an account of the total eclipse of 1901 May 18 (*Proc. R.S.* vol. lxix.), it is stated that the observed duration of totality at Aoer Gadang, Sumatra, was 10^s less than that predicted by the *N.A.*, but agreed closely with a prediction based on a value of 15′ 31″·47 for the geocentric mean semidiameter of the Moon. This value, Dr. Downing informs me, was arrived at by Herr Peters (of the Berlin *Jahrbuch*) after a discussion of the eclipse of 1900 May 28.

If we adopt this value for the Navalmoral eclipse, totality

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should have lasted 82s·4. The loss of 2s·4, needed to produce agreement with our observations, could be accounted for by a reduction of only 0″·5 in the Moon's semidiameter, *i.e.* of 1″ in her diameter. This discrepancy may reasonably be attributed to irregularities in the Moon's limb, as suggested by Mr. Crommelin in *Monthly Notices*, vol. lxi. pp. 52–3. A lunar valley of a depth of about 6,000 feet below the Moon's mean level, or two valleys, the sum of whose depths amounts to 6,000 feet, one valley being near second and the other near third contact, would be sufficient.

As the points of second and third contact were about position angles 93° and 271°, and the Moon's north pole at the time of the eclipse was 11° 13′ W. of her north point, the position angles of contact on the Moon's limb would be about 104° and 282° from her north pole. The Moon's libration in latitude was practically zero, that in longitude was +4°. The position angles may easily be 1° or 2° in error, for an extremely slight deviation from central transit produces a considerable change in these angles. The angles 99° and 267°, given by the *Nautical Almanac*, would apparently correspond to a difference of some 2″ between the centres of the Sun and Moon about mid-totality.

Adopting the angles 104° and 282°, second contact of the Moon with the Sun would occur near 86° E. longitude and 14° S. latitude, whilst third contact would be near 94° W. longitude and 12° N. latitude. The second contact indicates a region between the Cordilleras and the D'Alembert Mountains. The third contact is not on the lunar maps, being on that face of the Moon not shown by them, but the region indicated is in the neighbourhood (N.W.) of Neper, a walled plain.

Mr. Saunder, to whom I wrote about these localities, remarks that it is not possible, from our present knowledge, to say whether the neighbourhood of the Moon's limb near the contact points is above or below the mean level. But he adds that this information might be obtained from photographs taken during the eclipse, or taken at times when the Moon was under libration, similar to that which she had during the eclipse.

It is well known that the lunar border in the vicinity of second contact was seen to be very irregular during the progress of this eclipse. It will be of interest for some one possessed of suitable lunar photographs to investigate the regions of the Moon's limb referred to above.

Dr. Struve (*Monthly Notices*, vol. lii. p. 283) states that there is no systematic deviation of the form of the Moon's disc from a circle, and Professor Franz (*Monthly Notices*, vol. lxi. p. 264) concludes that the Moon's figure is sensibly spherical. Thus surface irregularities seem to be the only thing left to account for the discrepancy, still outstanding at Navalmoral, when Herr Peters's value of the semidiameter is used.

The estimated value of the Moon's telescopic mean semidiameter has undergone some interesting changes. According to the late Mr. Stone (*Monthly Notices*, vol. xlii. p. 42) the

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adopted value for 1750–1815 was 15′ 34″·27; for 1816–39 it was 15′ 33″·95; for 1840–61 it was 15′ 34″·68; and in and after 1862 it was 15′ 34″·08. The present (1900) value used in the *Nautical Almanac* is 15′ 34″·09, the mean horizontal parallax being 57′ 2″·28.

In the Preface to the *Nautical Almanac* for 1897 there appeared, for the first time, special values of the semidiameters of the Sun and Moon for use in eclipses and occultations, the value for the Sun being 15′ 59″·63 (Auwers), and for the Moon 15′ 32″·65 (Struve). For 1900 the American Ephemeris adopts 15′ 31″·76 for the eclipse semidiameter of the Moon.

There seems to be but little doubt that we need to use *three* different values for the Moon's semidiameter; the largest value for ordinary telescopic purposes, the intermediate for the occultations of stars, and the smallest for solar eclipses.

I would draw the attention of those interested in this subject to a very able article by Professor Oudemans, published in the *Monthly Notices*, vol. xxvi. pp. 249–260, 1866 May. He therein discusses the duration of occultations and eclipses, refers to the effect of indentations on the Moon's limb, and draws the conclusion that for occultations the Moon's mean semidiameter is 15′ 32″·27, but that for eclipses it is only 15′ 31″·02. The difference 1″·25 between these values agrees very nearly with the difference 1″·18 between the *Nautical Almanac* value, 15′ 32″·65, and that recently deduced by Herr Peters, 15′ 31″·47.

I am much indebted to Mr. Crommelin for independent confirmation of the principal computations in this paper.

Leeds: 1901 *December.*

Mean Areas and Heliographic Latitudes of Sun Spots in the Year 1901, deduced from Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. lxi. p. 533, and are deduced from the measurements of photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in 1901; and Table II. gives the same particulars for the entire year 1901 and the twelve preceding years for the sake of comparison. The areas are given in two forms: first, projected areas, that is to